

**CHAPTER 11**  
**PRESENTATION OF EQUIPMENT**  
**LESSON PLAN 11**

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**METHOD:**

Lecture, conference, and demonstration

**TIME ALLOTTED:**

1.5 hours

**COURSE PRESENTED TO:**

- a. Instructors
- b. Unit NCOs
- c. TSC personnel

**TOOLS, EQUIPMENT, AND MATERIALS (Per Student):**

- a. Student handout
- b. TM 9-6920-710-12&P-1
- c. TM 9-6920-711-12&P-1

**PERSONNEL:**

- a. Primary instructor
- b. Assistant instructor

**INSTRUCTIONAL AIDS:**

- a. Overhead projector
- b. Viewgraphs (Appendix A)

**REFERENCES:**

- a. TM 9-6920-710-12&P-1
- b. TM 9-6920-711-12&P-1
- c. Student Handout (Appendix B)

**APPENDICES:**

Appendix A. Viewgraphs  
Appendix B. Student Handout

## 11-1. INTRODUCTION.

(5 minutes)

Note. Show Slide 1.

- a. **Reason.** To be able to teach, instruct, and assist crews using PGS, the instructor must have an in-depth knowledge of the operation, function, and capabilities of PGS and its components.

Note. Show Slide 2.

- b. **Training Objective.** In a classroom environment, given a student handout and TM 9-6920-710-12&P-1 and TM 9-6920-711-12&P-1, you will become familiar with the function and capabilities of PGS and its components.
- c. **Procedure.** During this block of instruction we will discuss the functions and capabilities of PGS and its components.

## 11-2. LECTURE/CONFERENCE/DEMONSTRATION.

(80 minutes)

Note. Show Slide 3.

- a. **PGS Design.** The PGS training system consists of two parts: the PGS simulator, consisting of components that are mounted to the M2/M3 series BFV and the Training Data Retrieval System (TDRS), consisting of a computer unit and software used to set up and evaluate PGS training.
  - (1) **PGS simulator.** The PGS simulator can be divided into two sub-systems: firing system (FS) and target system (TS). The firing system performs the simulations of TOW, 25 mm gun, and coax firing. The target system performs the simulations of the effect of an ammunition impact on the vehicle. Some of the components that make up the PGS simulator are used both by FS and TS.
  - (2) **TDRS.** The TDRS contains a laptop computer with software to set up exercises with training data and evaluate and store data collected during PGS training. Data is transferred between simulator and computer by the TDRS memory card.

Note. Show Slide 4.

- (3) **Major components of firing system.**
  - (a) **Transceiver unit.** The transceiver unit performs the ballistic calculations and all the transmissions/receptions of coded laser pulses needed to complete a simulation.
  - (b) **Tracer, burst, obscuration simulator (TBOS) system.** Simulates visual effects of firing in the commander's and gunner's sights of the M2/M3 BFV.

## 11-2. LECTURE/CONFERENCE/DEMONSTRATION (Con't).

Note. Show Slide 5.

- (4) **Major components target system.** This system performs the target simulation for a vehicle under attack by TWGSS/PGS or MILES firing vehicles. It simulates the target outline and vulnerability of the vehicle it simulates. The TS consists of:
  - (a) Target computer unit
  - (b) Retro detector units (4)
  - (c) Hull defilade detector units (4)

Note. Show Slide 6.

- (5) **Common components.** The following components are common to both firing and target systems:
  - (a) Remote system interface (RSI) assembly. This assembly stores data on vehicle position and provides system time monitoring/updating to PGS.
  - (b) Vehicle interface assembly. This assembly monitors and injects signals into the vehicle to allow the crew to perform normal gunnery procedures with a simulator. Both firing and target systems use the vehicle interface assembly during simulation.
  - (c) Operator interface. The control panel is the operator interface between PGS and the crew. The control panel allows the downloading of PGS training parameters and storage of training data collected during the training exercise. Both FS and TS data is presented and stored.

Note. Show Slide 7.

- (6) **System bus.** Major components in PGS are linked together on a high-speed data bus called Controller Area Network (CAN). This link is similar to the 1553 link used in the M1A2. The high-speed data bus is used for communication between components within the system and to distribute power to all PGS components. The data bus connects to transceiver unit, TBOS driver unit, target computer unit, vehicle interface unit, and control panel.

Note. Show Slide 8.

- b. **Transceiver Unit.** The transceiver unit uses conditionally eye-safe laser transmitters for the simulation of projectiles and TOW family of missiles. The laser transmitters use laser light compatible with the lasers used by MILES. PGS simulates projectiles and missiles in real time and with the correct ballistics and dynamics of real ammunition. The transceiver unit performs the simulation of projectiles and TOW missiles based on firing tables for combat ammunition, thereby enabling precision gunnery.

## 11-2. LECTURE/CONFERENCE/DEMONSTRATION (Con't).

Note. Show Slide 9.

- (1) **Functional principle of laser light simulation.** Laser light cannot replicate the curved trajectory of a projectile or a guided missile due to the fact that it is much faster and does not travel in a curved trajectory. In order to use laser light to simulate a projectile, the transceiver unit must combine ballistic calculation, laser light transmission and reception, and gyro stabilization into a simulation of a fired projectile.
  - (a) The transceiver unit performs the complete ballistic simulation. The computer inside the transceiver unit calculates the position of the projectile/missile it simulates continuously throughout the flight path. The simulation of the projectile or missile is in real time and according to firing table data.
  - (b) In order to use laser light to simulate a curved projectile, the system continuously transmits pulses around the position where the simulated projectile is located during its trajectory. Each pulse is transmitted and evaluated for received reflections. The system scans the pulses around the position of the projectile.
  - (c) Targets used during PGS training must be equipped with retro detector or reflector units in order for the transceiver unit to determine an impact point on the target.

Note. Show Slide 10.

- (2) **Flying volume.**
  - (a) The transceiver unit contains laser transmitters that send out laser pulses that are shaped as long narrow lobes. These laser pulses are transmitted continuously during simulation to detect targets. By combining scanning, transmission, and reception of laser lobe pulses, a flying volume is created around the simulated projectile. The flying volume is simulated with the same ballistics as the actual projectile. The reference used for simulation is the direction of the gun barrel at the instance of the simulated round leaving the muzzle.

Note. Show Slide 11.

- (b) The flying volume is moved forward with the speed of the simulated projectile. Laser pulses are scanned around where the round is positioned in the air. Only laser pulses reflected from targets positioned within the flying volume are acce-

## 11-2. LECTURE/CONFERENCE/DEMONSTRATION (Con't).

pted by the transceiver unit. 50,000 pulses can be sent out during a simulation to detect targets. Each pulse transmitted is evaluated for a returned reflection from a target within the flying volume.

Note. Show Slide 12.

### (3) Gyro stabilization.

- (a) The flying volume is stabilized during simulation by the gyros of the transceiver unit. This enables fire on-the-move or movement of the gun barrel during simulation without the projectile following the gun barrel movement.
- (b) The same gyro compensates for cant angle if the round is fired with the vehicle positioned with cant. This will enable the round to drop correctly in relation to the ground plane.
- (c) The gyro is also used to adjust the TOW missile's flight path. The tracking movement of the gunner is sensed and the missile's flight path is adjusted with the guiding movements.

Note. Show Slide 13.

### (4) Impact point determination.

- (a) Impact point determination occurs when the flying volume (simulated projectile) has reached the retro detector/reflector-equipped target and reflections from the target are detected by the transceiver unit. These reflections are used to determine the simulated projectile's impact in relation to the retro reflector.
- (b) The system uses three lasers shaped like narrow, long beams. The beams are used (through scanning) to determine where the retro reflector-equipped target is positioned in relation to the simulated round.
- (c) The information of where the simulated round will impact together with the ammunition type fired and identity of firing vehicle is transmitted to the target by the transceiver unit when impact point determination is in progress.
- (d) Impact point and ammunition type information enable the target system to perform an independent evaluation of the round impact effect. This evaluation is based upon pre-programmed target system data like vehicle type, size, outline, and vulnerability.

Note. The firing system cannot distinguish between target vehicle types. The firing system only calculates the impact point in relation to the retro detector/reflector and transmits the impact point and ammunition type to the retro reflector.

## 11-2. LECTURE/CONFERENCE/DEMONSTRATION (Con't).

Note. Show Slide 14.

### (5) Engagement results.

- (a) The transceiver unit evaluates the firing system engagement by comparing the determined impact result with a template. If the impact is within the template, the simulation is stopped and the result of the engagement is presented. If the impact is outside the template, the simulation continues in search of other targets.
- (b) The fired upon target system, based upon the received impact point and ammunition type, calculates the effect on the target vehicle. This is done independently of the firing system's evaluation. The correct vehicle impact result during a force-on-force exercise is found in the target system.

Note. Show Slide 15.

### (6) Ballistic simulation. The transceiver unit performs the ballistic simulation for the various rounds and TOW missiles based on firing table data and flight dynamics of missiles. The following data is used:

- (a) Ballistic trajectory, velocity, and time of flight of the M791 AP and HEI-T 25 mm rounds.
- (b) Ballistic trajectory, velocity, and time of flight of the coax M60 type round.
- (c) Flight dynamics, velocity, and time of flight of the TOW family.
- (d) PGS is system accurate within  $\pm 0.2$  mils. If desired, the trainer can program an ammunition dispersion of  $\pm 0.5$  mils for AP and HE and  $\pm 1.0$  mils for coax.

Note. Show Slide 16.

### (7) Information transmission to target system. The firing system transmits information to the target system. This information is used by the target system to calculate the impact point and the effect of a round on the target. The following information is transmitted:

- (a) Hit position in elevation and azimuth. This is used by the PGS target system to determine impact point in the target.
- (b) Ammunition type fired. This is used by the PGS target system in the calculation of impact effect.
- (c) Player identification. This is stored by the target system and is used for result pairing during the AAR.

## 11-2. LECTURE/CONFERENCE/DEMONSTRATION (Con't).

- Notes.
1. The MILES information is transmitted at the impact point of the simulated round.
  2. The MILES information is sent at the aiming point used for targets that are not equipped with a retro reflector. The MILES transmission is performed after the completed firing simulation

- (d) MILES. The transceiver unit transmits MILES firing information after a completed PGS simulation in order for LTIDs and MILES target systems to function.

Note. Show Slide 17.

### (8) Transceiver unit mounting on rotor extension.

- (a) Protection. The unit is mounted inside the mounting bracket for protection against dirt and damage. The unit is sealed and protected against vibration and shock.
- (b) Transceiver unit position. Because the transceiver unit is mounted on the rotor of the gun, it is able to pick up gun/sight misalignment at the moment of trigger pull. These misalignments normally occur due to vibration when firing on the move over rough terrain.
- (c) Misalignment of gun/sight relationship. The simulation will be affected by crew-induced errors such as incorrect boresighting. This requires the crew to correctly perform the prepare-to-fire and boresighting procedures.
- (d) Mechanical play between sight and gun. Mechanical or electrical errors within the turret weapons will show up as errors in the result of the simulation.

- c. **Tracer, Burst, Obscuration Simulator (TBOS) System.** The TBOS system simulates the effects of rounds fired with 25 mm gun, coax, and TOW.

Note. Show Slide 18.

### (1) TBOS system design.

- (a) The TBOS driver unit initiates and computes the TBOS simulation.
- (b) The TBOS eyepiece units present TBOS effects through a semi-transparent mirror in the ISU and ISUCE fields of view.
- (c) The TBOS driver unit is connected to the CAN data bus.

Note. Show Slide 19.

- (2) **TBOS effects.** The TBOS effects are presented in the ISU and ISUCE day and thermal modes. The following effects are presented:

## 11-2. LECTURE/CONFERENCE/DEMONSTRATION (Con't).

- (a) Tracer simulation. Tracer effects are simulated in all sights with realistic burn times and zooming effects. The tracer effects can be switched off.
- (b) Burst simulation. Burst on target and burst on ground are simulated. The size is dependent on ammunition type and on the range to the impact. Ground burst effects are smaller than burst on target effects. Burst effects can be switched off.
- (c) Obscuration simulation. Obscuration is simulated for TOW firing only. The instructor can program the obscuration time from 0-5 seconds.

Note. Show Slide 20.

- (3) **Tracer template.** The visual effects of the TBOS simulation are controlled by a template. The template sizes used are T80 frontal for TOW, BMP frontal for AP and HE, and a kneeling soldier for coax. The following happen with TBOS effects when firing in the different template areas:

- (a) Area A. If area A is hit, simulation is stopped. A burst on target indication is given. Burst on target indication is bigger than burst on ground indication.
- (b) Area B. If area B is hit, simulation is stopped prior to reaching the target and burst on ground indication is given at the impact point between projectile and a simulated ground plane.
- (c) Area C. If area C is hit, simulation continues until the simulated projectile reaches maximum simulated range (if this happens prior to a ground hit) or hits the simulated ground plane.
- (d) Area D. If area D is hit, the tracer simulation stops at the top of the template or the simulation continues (with the tracer simulation switched off) until the ammunition reaches maximum range simulated or the simulated ground plane.

Note. Show Slides 21, 22, and 23.

- (4) **TBOS system components.**

- (a) The TBOS system for the BFV consists of a TBOS driver unit and two TBOS eyepiece units, one for gunner's sight and one for commander's sight.
- (b) The TBOS driver unit initiates the TBOS simulation and calculates tracer position, burst indications, etc. into the TBOS eyepiece units.
- (c) The TBOS eyepiece units present TBOS effects into the optics of the BFV sights.



## 11-2. LECTURE/CONFERENCE/DEMONSTRATION (Con't).

Note. Show Slide 24.

- d. **Target System.** The target system determines if a projectile hits or misses the target. If the target is hit, the system simulates the effect the projectile would have on the vehicle. The effect of the round is indicated with strobe lights and sound cues in the intercom. Each round fired at the target is individually evaluated. Accumulative effects, of firing in the same area of a target, are not considered during target system evaluation.

Note. Show Slide 25.

- (1) **System design of target system.** The block diagram shows the connections of retro detector units (RDUs) and hull defilade detector units (HDDUs) to the target computer unit (TCU). The TCU is connected to PGS through the CAN link.

Note. Show Slide 26.

### (2) Target system main functions.

- (a) **Receive information.** The target system receives information from TWGSS/PGS- or MILES-equipped vehicles. The target system also receives information from control guns (CGUNs).
- (b) **Determine angle of attack.** The target system is equipped with eight detectors which are used to define 12 sectors. Each sector is 30°, providing a total of 360° coverage. Each of these 12 sectors replicates the target's outline, size, and vulnerability.
- (c) **Determine MISS/HIT.** The target system determines HIT or MISS based upon received hit coordinates and target aspect angle.
- (d) **Determine MOBILITY KILL/WEAPON KILL.** If the vehicle is assessed as HIT, the target system determines if a MOBILITY KILL or WEAPON KILL has occurred. The type of kill is based upon the actual impact point of the round on the target (suspension/track or weapon components) and the target's aspect angle.
- (e) **Determine catastrophic KILL.** If the vehicle is HIT (not MOBILITY KILL or WEAPON KILL), the probability of kill is assessed based upon vulnerability data. A random generator is used to determine if vehicle is KILL or only considered hit. The higher the kill probability the higher the chance to be killed.
- (f) **Indicate the effect.** The effect of the round impact is indicated to the firing vehicle through the strobe lights of the target vehicle's retro detector units. The effect is indicated to the crew in the target vehicle through the sound cues in the intercom.

## 11-2. LECTURE/CONFERENCE/DEMONSTRATION (Con't).

Note. Show Slide 27.

- (3) **Information received by target system.** The target system can receive information from laser-based simulators (TWGSS, PGS, CGUN, and MILES). The following information can be received:
- (a) Hit coordinates. PGS receives hit positions in azimuth and elevation from other TWGSS or PGS systems. The hit coordinate is in relation to the retro reflector. The aspect angle of the attack is determined by the detector that received the coded message.
  - (b) Type of ammunition fired. PGS transmits the type of ammunition fired to allow the target system to make an assessment of the hit/kill probability at the impact point.
  - (c) Identity of attacking system. The identity of the attacker is also sent to the target system and stored together with the target simulation results. This provides target pairing during AAR.
  - (d) MILES information. If the attacker is a MILES-equipped vehicle, the ammunition type, identity, and effect of the simulation is indicated and stored by the target system.
  - (e) Control gun (CGUN) information. Instructors using the CGUN can transmit information to PGS target systems. This allows the controller to reload, reset, kill, and test vehicles during PGS training.

Note. Show Slide 28.

- (4) **Tamper indications.** The system senses, indicates, and stores any attempts to tamper with PGS. Tamper is indicated on the control panel, with strobe lights, and on the TDRS memory card. The following tamper attempts are indicated and stored:
- (a) Disconnection of retro detector units. If a RDU cable is disconnected, tamper is indicated. The crew has 30 seconds to reconnect before KILL is indicated.
  - (b) Disconnection of hull defilade detector units. If an HDDU cable is disconnected, tamper is indicated. The crew has 30 seconds to reconnect before KILL is indicated.
  - (c) Disconnection of power. The system stores every powerup on the TDRS memory card. This indicates to the instructor during the AAR that the vehicle or PGS was switched off during training.
  - (d) Alteration of control panel functions. If ammunition or other training parameters have been altered, it will be identified during the AAR.
  - (e) Disconnection of system cables. Any cables disconnected within the system will be stored as BIT errors on the TDRS memory card.

## 11-2. LECTURE/CONFERENCE/DEMONSTRATION (Con't).

- (f) Removal of TDRS memory card. If the TDRS memory card is removed and reinserted, this will be noted on the TDRS memory card.

Note. Show Slide 29.

- (5) **Target system template.** The target system uses a template to determine HIT/MISS and target vulnerability. The template is programmed to accurately resemble vehicle's size and vulnerability for each of the ammunition types.

- e. **RSI Assembly.** The RSI interfaces PGS and the global positioning sensor (GPS).

Note. Show Slide 30.

- (1) **RSI position.** The RSI is connected between the target computer unit and the TBOS driver unit. The antenna for the RSI is connected to the RSI assembly.

Note. Show Slide 31.

- (2) **RSI main functions.**

- (a) Position defemination. The RSI determines the position of each PGS in an exercise. Every 50 m of movement is logged and stored on the TDRS memory card for AAR. Each event is stored with position data. The RSI is required to determine PGS position within a 50 m radius of actual.
- (b) System time. The RSI receives the actual time from the satellite and adjusts the PGS clock as necessary. This ensures that all systems in the exercise use the same time to time tag training events. This simplifies result pairing during AAR.

Note. Show Slide 32.

- (3) **RSI system components.** The RSI system consists of:

- (a) RSI assembly. This assembly determines vehicle position.
- (b) GPS antenna. This antenna receives signals from the satellite.

- f. **Vehicle Interface Assembly.** The vehicle interface assembly consists of components used by both firing system and target system.

## 11-2. LECTURE/CONFERENCE/DEMONSTRATION (Con't).

Note. Show Slide 33.

- (1) **Vehicle interface assembly system design.** The block diagram shows the connections between the vehicle's diagnostic test panel (DTP) and the expansion unit. Also shown are connections of the various PGS interface components. The vehicle interface assembly is connected to PGS through the CAN link.

Note. Show Slide 34.

- (2) **Vehicle interface assembly main functions.** The vehicle interface assembly is the link between PGS and the BFV. The main function of this interface is:
  - (a) Receive and distribute power. The vehicle interface unit receives 24 volts from the vehicle's DTP J1. This power is converted, stabilized, and distributed to all PGS components.
  - (b) Monitor and inject signals to and from turret weapons. PGS is interfaced with the BFV and its turret weapons through the DTP. The simulator sends and receives signals to the vehicle through these connections via the vehicle interface.
  - (c) Monitor turret weapon status for AAR. Some vehicle signals are stored for use with the AAR. Some of these signals are ammo selected, ammo fired, and range selected on range knob.
  - (d) Register turret/hull relationship. PGS stores the turret/hull relationship through the commander's turret position indicator (TPI). This information is used for target simulation and AAR.
  - (e) Inject sound into the vehicle intercom. The vehicle interface unit injects sound cues into the vehicle intercom to simulate various firing systems, target system, and BIT functions.
- (3) **Vehicle interface assembly main components.** The main components of the vehicle interface assembly consist of:

Note. Show Slide 35.

- (a) Vehicle interface unit. This unit receives power from the vehicle and provides power to PGS. It processes the interface signals to and from the vehicle.

Note. Show Slide 36.

- (b) Expansion unit. This unit receives and sends signals to the turret weapons. It communicates turret weapon status to the vehicle interface unit.

## 11-2. LECTURE/CONFERENCE/DEMONSTRATION (Con't).

Note. Show Slide 37.

- g. **Operator Interface.** PGS is operated through the control panel. The control panel uses four pushbuttons to operate menus containing all the functions needed to align, test, and train with PGS.

Note. Show Slide 38.

### (1) **Control panel main functions.**

- (a) Crew/instructor interface. The control panel interfaces the crew and/or the instructor with PGS.
- (b) Setup of system. The TDRS memory card downloads application-specific data such as ballistics, parallaxes, target templates, etc. at system startup.
- (c) Defines training parameters. Training data such as training mode, ammunition allowances, obscuration time, etc. is defined on the TDRS memory card. The TDRS data is programmed by the instructor prior to training and downloaded into the system during powerup.
- (d) Stores training events. The TDRS memory card stores training events for the After Action Review (AAR). The AAR can be presented to the crew using the TDRS computer unit.

Note. Show Slide 39.

### (2) **Control panel crew functions.** The crew uses only part of the control panel's capabilities during a training exercise. The following tasks are performed by the crew:

- (a) Built-in test (BIT). The crew verifies the system is operational prior to, during, and after training.
- (b) Alignment. The crew aligns the system to the vehicle prior to training.
- (c) Upload of ammunition. The crew uploads ammunition from hull to turret.
- (d) Presentation of training result. The crew uses the control panel to receive firing results and, if fired upon, target results during training.

Note. Show Slide 40.

### (3) **Control panel instructor functions.** The instructor accesses a special control panel menu through the CGUN transmission of a special access code. This menu allows the instructor to perform the following:

- (a) Time adjustment. Time is manually adjusted using the control panel.

## 11-2. LECTURE/CONFERENCE/DEMONSTRATION (Con't).

- (b) Turret ammunition adjustments. The instructor adds or removes ammunition in the turret without the use of the TDRS computer unit.
- (c) Hull ammunition adjustments. The instructor adds or removes ammunition in the hull without the use of the TDRS computer unit.
- (d) View position. The instructor can view the position of the vehicle to determine the position of a target during setup of a new gunnery scenario.

Note. Show Slide 41.

h. **System Cables**. The system uses two types of cable connectors. These are:

- (1) **Military standard (MS) connector**. This connector is mainly used for connections to the vehicle.
- (2) **Push-pull connector**. This connector is normally used for connections within PGS.

Note. Show Slide 42.

i. **Control Gun (CGUN)**.

(1) **CGUN features**.

- (a) Rifle stock. This feature provides the user with support for long range shots.
- (b) Laser transmitter. This eye-safe battery powered laser transmitter has a 2000 m range capacity.
- (c) Scope. This 4X scope provides accuracy at long ranges.

Note. Show Slide 43.

(2) **CGUN messages**. The following information can be transmitted using the CGUN:

- (a) KILL. This message is used by the instructor to kill vehicles.
- (b) RESET. This message is used by the instructor to activate killed vehicles and allow them to continue training. RESET also restores ammunition load to the preprogrammed amount.
- (c) TEST. This message is used by the instructor to verify that PGS is activated and functional.
- (d) TIME MARK. This function is used by the instructor to time tag events.
- (e) ENABLE CONTROL. This function enables the instructor to upload ammunition and reset systems during training without the use of the TDRS computer unit.

## 11-2. LECTURE/CONFERENCE/DEMONSTRATION (Con't).

Note. Show Slide 44.

- j. **Retro Reflector Unit.** The retro reflector unit is designed to be installed on panel targets and used for panel gunnery. They can also be installed on MILES-equipped vehicles to provide "cooperative MILES targets."

## 11-3. FINAL REVIEW. (5 minutes)

- a. **Student Questions.**

Note. Show Slide 45.

- b. **Summary of Main Teaching Points.**

- (1) PGS components and their function
- (2) CGUN

Note. Show Slide 46.

- c. **Closing Statement.** This block of instruction has provided the instructor with an in-depth knowledge of PGS. The knowledge gained in this lesson will be of use when you train soldiers in your unit.

**APPENDIX A  
TO LESSON PLAN 11**

**PRESENTATION OF EQUIPMENT**

**VIEWGRAPHS**

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## APPENDIX B TO LESSON PLAN 11

### PRESENTATION OF EQUIPMENT

#### STUDENT HANDOUT

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##### B-1. SCOPE.

This handout includes a basic description and principle of operation of the following:

- a. Simulation with laser light
- b. The PGS firing system
- c. The PGS target system

##### B-2. SIMULATION WITH LASER LIGHT.

- a. PGS uses a low-power laser which is classified as eye-safe. It differs from the laser used in fire control equipment rangefinders, which has far greater power and requires adherence to strict safety regulations. The laser light used in PGS is compatible with the laser light used by MILES. This means that the lasers transmit light at the same frequency.
- b. Laser light travels in a straight line at a very high velocity, the highest velocity known. Therefore, it cannot be used directly to simulate a curved projectile trajectory. Compared with the speed of laser light, the projectile moves at a very low speed. A laser pulse reaches a target 1000 m away in about 3.3 microseconds ( $3.3 \times 10^{-6}$ ). It takes 200,000 times longer (0.7 s) for a projectile to reach the same target if the velocity of the projectile is 1450 m/s. (See Figure 1).

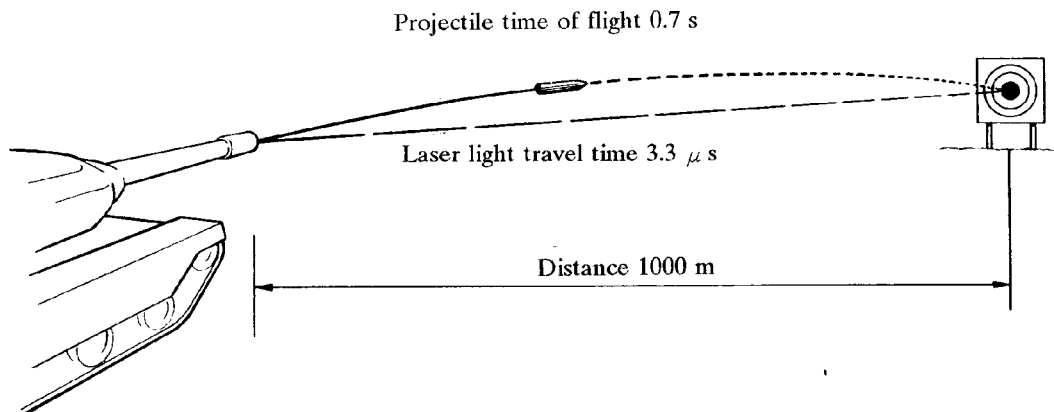


Figure 1.

## B-2. SIMULATION WITH LASER LIGHT (Con't).

- c. Targets used during precision gunnery training with PGS must be equipped with retro reflector units which reflect the light back to the firing system. The retro reflectors are used to determine where the simulated round hits in relation to the target.

## B-3. PGS FIRING SYSTEM.

- a. The firing system goes through a cycle each time the system simulates firing. The only exception is the ammunition assignment which is performed when the TDRS memory card is downloaded at PGS powerup. Ammunition selection, sighting, and firing are manual steps, while other parts of the cycle are carried out automatically by the firing system.
- b. All steps in the firing system simulation cycle are illustrated in Figure 2 and described as follows:

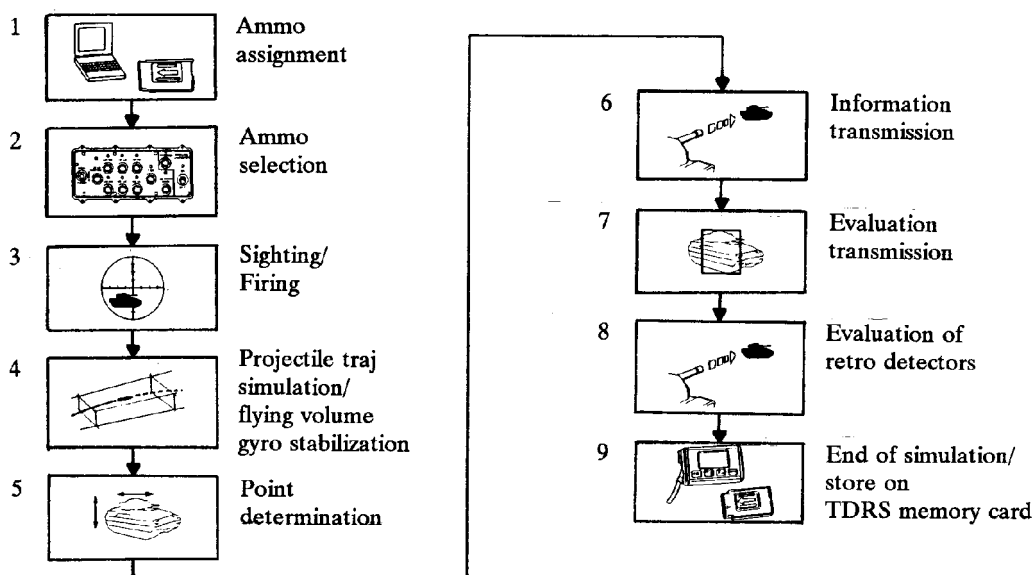


Figure 2.

### **B-3. PGS FIRING SYSTEM (Con't).**

#### **(1) Ammunition assignment.**

Note. Refer to detail 1 of Figure 2.

- (a) Before the training exercise starts, the vehicle is assigned ammunition by the instructor who programs the TDRS memory card using the TDRS computer unit. When PGS is powered up, the data from the TDRS memory card is downloaded into PGS.
- (b) The data contains information on how much and which type of ammunition the system will carry during the exercise. The ammunition assignment is stored in a memory; each time the firing system simulates firing, the remaining ammunition is decreased.
- (c) If ammunition runs out during the exercise, new ammunition must be assigned by the instructor using the TDRS computer unit or a control gun (CGUN).

#### **(2) Ammunition selection.**

Note. Refer to detail 2 of Figure 2.

- (a) Ammunition selection is performed by use of the BFV weapon control box.
- (b) The firing system also has the capability to simulate ammunition stored in the hull of the vehicle. PGS simulates the time it takes to move the ammunition from the hull to the turret. The upload time is adjustable.

#### **(3) Sighting and firing.**

Note. Refer to detail 3 of Figure 2.

- (a) The vehicle's normal turret weapon and sights are used during engagements with PGS. Firing of a simulated round is carried out in the same way as during live fire.
- (b) PGS is programmed with combat ammunition based upon firing table data and flight dynamics.
- (c) The correct lead angle and superelevation of gun must always be applied for a successful engagement.

#### **(4) Projectile trajectory simulation.**

Note. Refer to detail 4 of Figure 2.

### B-3. PGS FIRING SYSTEM (Con't).

- (a) When a round is fired with PGS, simulation of the projectile begins in the transceiver unit. The purpose of this simulation is to determine the projectile's position in space continuously throughout the time of flight. This is done through ballistic calculations based upon firing table data.
- (b) Simulation starts in the direction the gun barrel is pointing at the instant a live projectile would have left the muzzle of the gun. This direction is called the reference direction (see Figure 3).
- (c) The reference direction is used as reference to calculate the position of the projectile during simulation. This direction is gyro stabilized which means that the gun barrel can move without affecting the simulated projectile's position during time of flight.

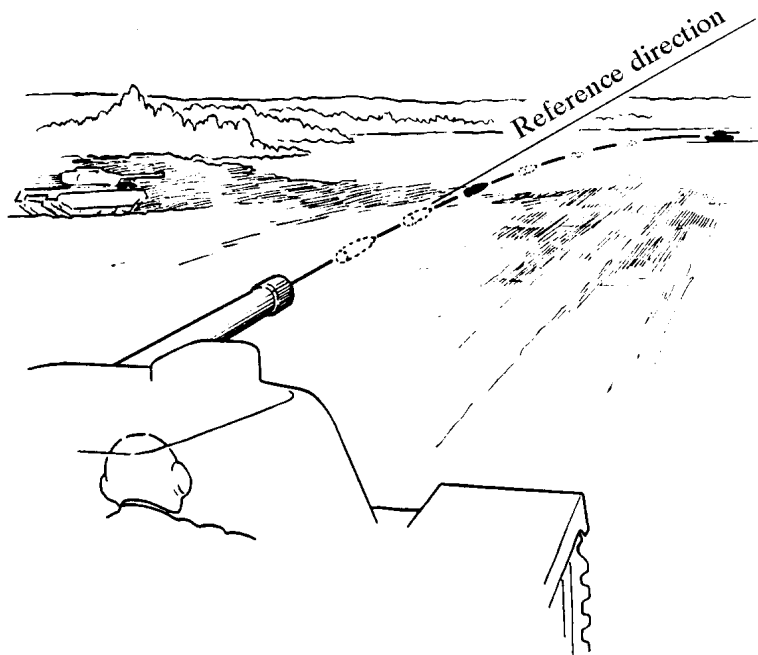


Figure 3.

#### (5) Flying volume.

Note. Refer to detail 4 of Figure 2.

- (a) Laser light is sent out from the transceiver unit in long, narrow, pulsed beams called lobes. By combining the transmission and reception of laser light within the transceiver unit, the firing system creates something called the flying volume (see Figure 4).

### B-3. PGS FIRING SYSTEM (Con't).

- (b) This flying volume follows the same trajectory the live fired projectile would have taken. It follows the projectile continuously, and the simulated projectile is always in the center of the volume. The flying volume has the same velocity and trajectory as the projectile and is continuously scanned by pulsed laser lobes from the transceiver unit.

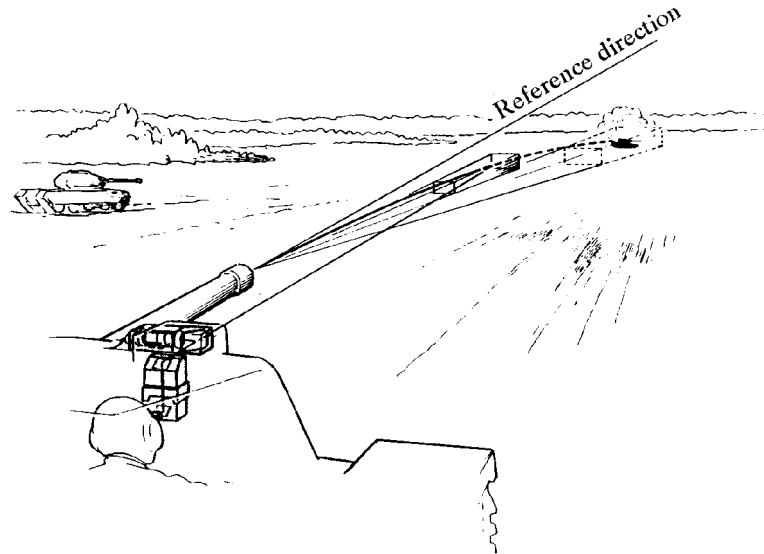


Figure 4.

- (c) Assume the gunner lays on a moving target and has applied the correct superelevation and lead angle. Since the flying volume follows the same trajectory as a live projectile and the flying volume velocity corresponds to that of the live projectile, it will cover the target at that instant when the projectile either strikes or passes the target. If a retro detector unit facing the firing vehicle has been mounted on the target, the laser light will be reflected back to the transceiver unit and the position of the target can be determined.
- (d) The dimension of the flying volume and its position is determined by the projectile simulated. The faster the round, the longer the flying volume.
- (e) The position of the flying volume is updated approximately 15 times per second and with the trajectory of the simulated ammunition type.
- (f) The position of the simulated projectile within the flying volume is updated approximately 200 times per second, through the ballistic calculation performed by the transceiver unit.

### B-3. PGS FIRING SYSTEM (Con't).

#### (6) Sweep.

Note. Refer to detail 4 of Figure 2.

The transceiver unit scans the laser lobes vertically and horizontally. This scan provides a horizontal sweep, as shown in Figure 5, which is used to search for targets within the flying volume. The vertical scan is used to lower the projectile during its trajectory simulation.

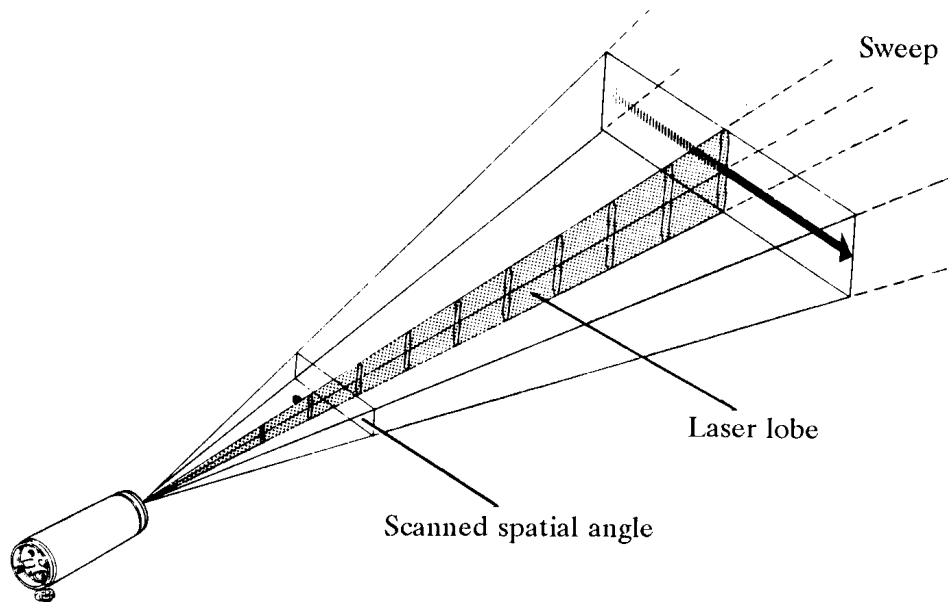


Figure 5.

#### (7) Projectile velocity.

Note. Refer to detail 4 of Figure 2.

The transceiver unit receives all reflections, but only those reflections which arrive from retro detector units located within the flying volume are processed. Figure 6 shows a target which is illuminated by laser light, but the flying volume has not yet reached the target. Therefore, its reflections are not yet processed by the transceiver unit.

**B-3. PGS FIRING SYSTEM (Con't).**

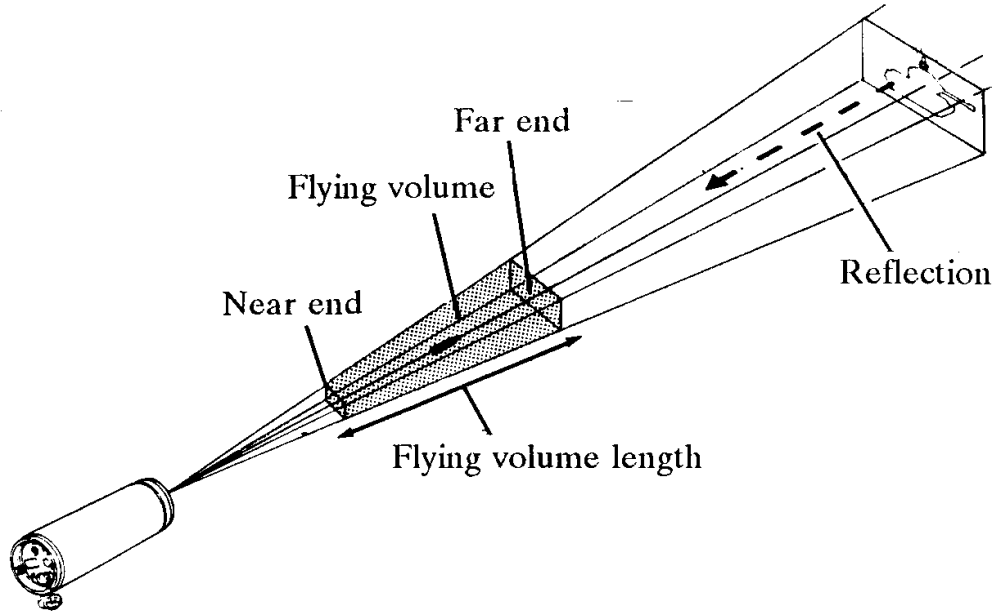


Figure 6.

**(8) Curved projectile trajectory.**

Note. Refer to detail 4 of Figure 2.

- (a) Since the actual projectile trajectory is curved, the laser lobes must be lowered as the simulated projectile moves away from the muzzle so the flying volume will always be located around the simulated projectile.
- (b) Figure 7, which is highly exaggerated, shows three different projectile positions during simulation. At the first position, the projectile has deviated very little from the reference direction. At the second position, the projectile has dropped and the flying volume (scanned area) must be lowered relative to the reference direction.

### B-3. PGS FIRING SYSTEM (Con't).

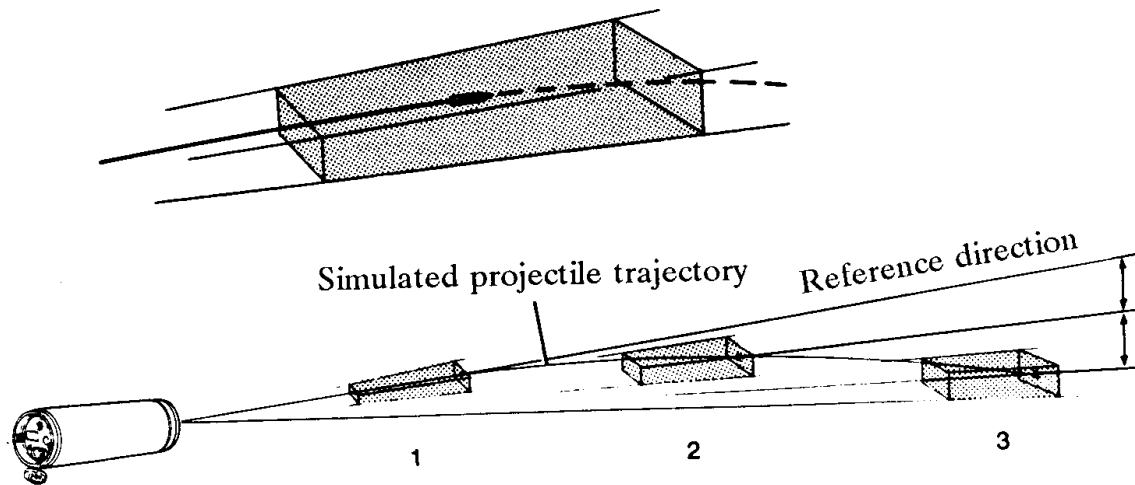


Figure 7.

#### (9) Gyro stabilization.

Note. Refer to detail 4 of Figure 2.

- (a) Gyros in the transceiver unit sense gun barrel movement. During the projectile's time of flight, the transceiver unit calculates the extent to which the gun barrel has moved away from the reference direction.
- (b) A gyro signal is generated which is used to:
  - 1. adjust the position of the sweep in order to stabilize the simulated projectile in the air;
  - 2. adjust the position of the tracer, burst, obscuration simulator (TBOS) simulation of the tracer in the tank's sight; and,
  - 3. calculate impact on the target.
- (c) If, for example, the gun barrel is moved to the left after firing, the sweep also moves to the left since the transceiver unit is mounted in the gun barrel. The gyros in the transceiver unit sense this movement, and a gyro signal is generated which moves the sweep to the right (see Figure 8). This means that the flying volume's sweep is kept in the same position as at the instant of firing (before the gun barrel was moved). As shown in Figure 8, the total deflection area is large relative to the sweep.



### B-3. PGS FIRING SYSTEM (Con't).

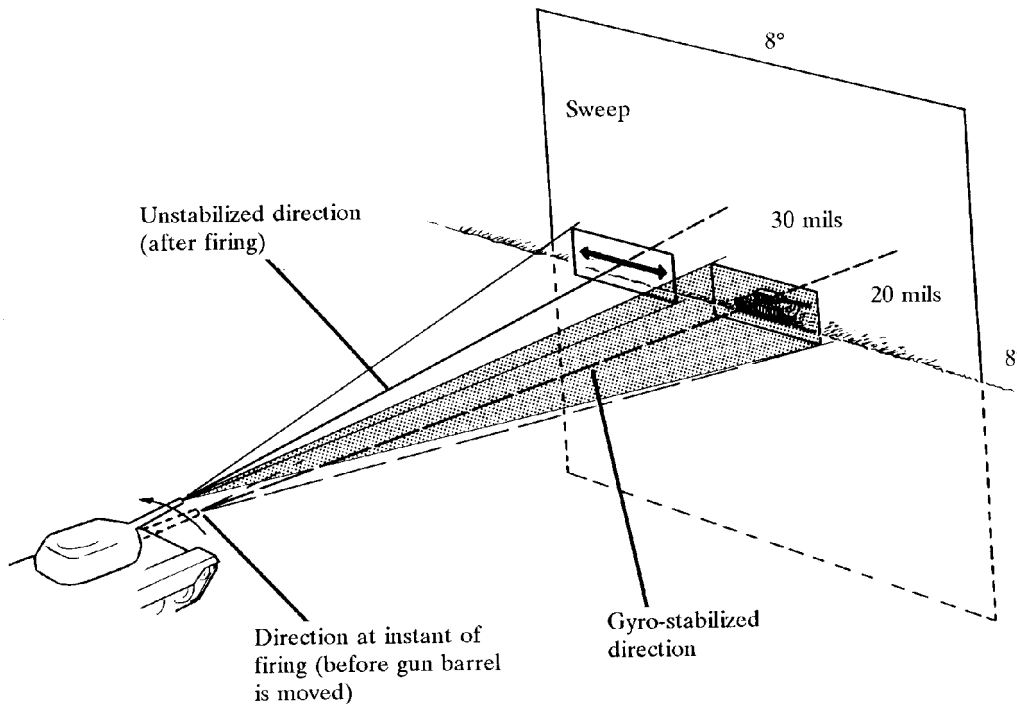


Figure 8.

#### (10) TBOS effects.

Note. Refer to detail 4 of Figure 2.

- (a) The TBOS effects of a projectile are simulated into the gunner's and commander's sights. The TBOS units are installed in front of the sights. These units contain a semi-transparent mirror on which the TBOS effects are projected (see Figure 9). The gunner and commander see the surrounding terrain through the mirror as well as the projected TBOS effects. This makes for a realistic TBOS effect.
- (b) For some vehicles, the TBOS effects are injected electronically into the sight of the vehicle. For these vehicles, there is no need to install the TBOS unit in front of the sight.
- (c) TBOS effects are ammunition dependent. The following TBOS effects are simulated:

### B-3. PGS FIRING SYSTEM (Con't).

1. Obscuration
2. Tracer
3. Burst on target
4. Burst on ground

- (d) The position of the tracer in the sight is controlled by the projectile trajectory simulation and gyro stabilization. This enables the tracer simulation to have the same trajectory as the simulated projectile. The size of the tracer is reduced as the distance between the projectile and the muzzle increases.

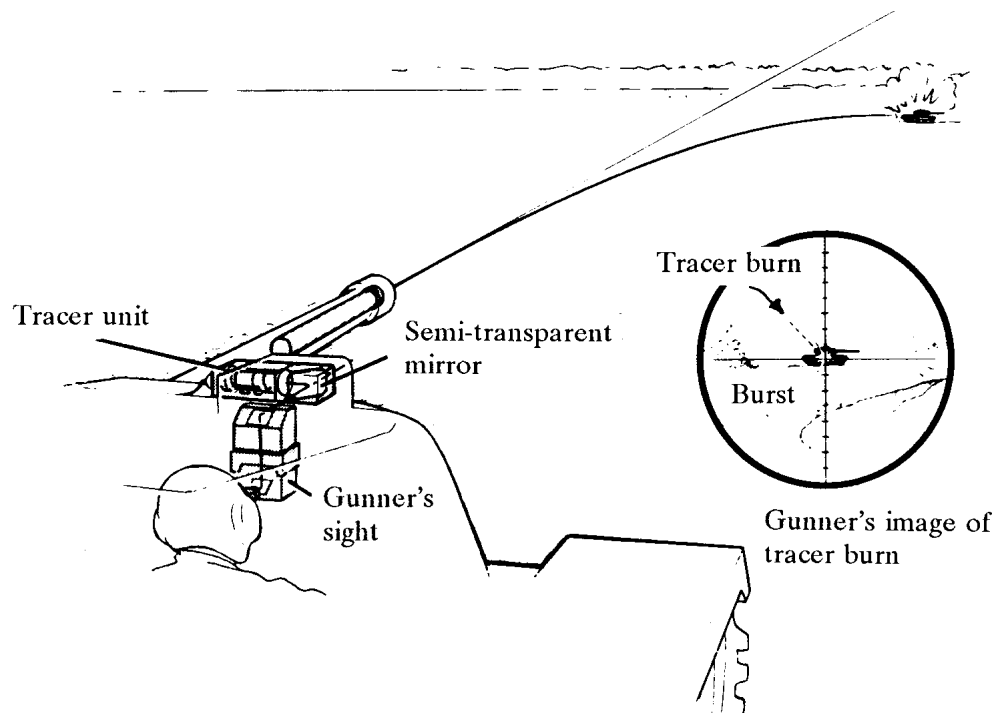


Figure 9.

- (e) If the simulated projectile strikes the target or the ground, there will be a burst simulating the impact. The burst on target effect is larger than a burst on ground effect. Different types of ammunition have different sizes of burst effect depending of the capability of that ammunition.

#### (11) Hit point determination.

Note. Refer to detail 5 of Figure 2.

**B-3. PGS FIRING SYSTEM (Con't).**

- (a) Hit point determination is carried out when the flying volume covers the target. Figure 10 shows the principles used to determine the point of impact for a laser lobe.

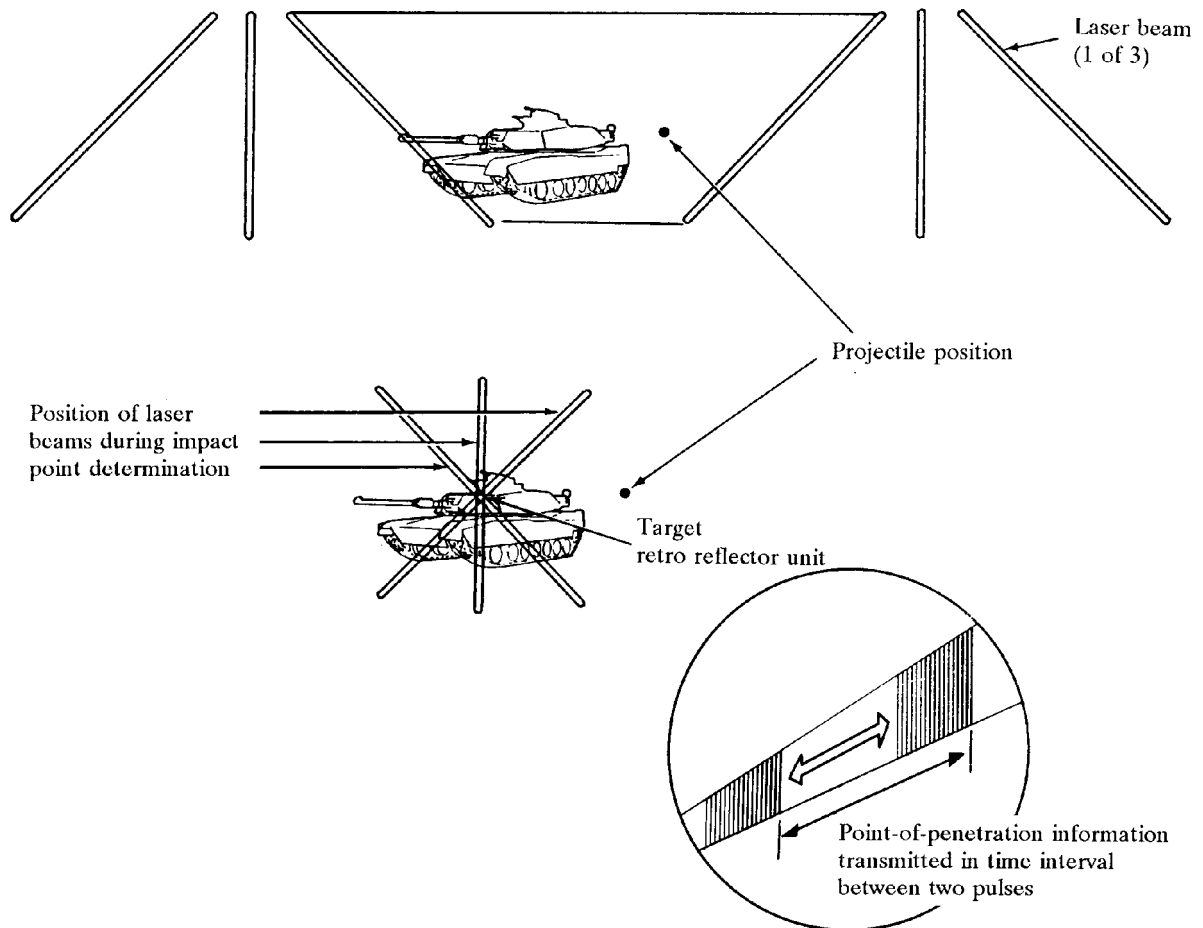


Figure 10.

### **B-3. PGS FIRING SYSTEM (Con't).**

- (b) The transceiver unit, which scans the lobes, provides continuous information about the current position of the lobes. When a reflection is detected by the transceiver unit, the angular position of the lobe is determined. The reference used for this reading is the direction of the simulated projectile at the instant of reflection.
- (c) The angle that is read is a measurement of the lateral position of the point at which the simulated projectile hits the retro detector unit on the target. By calculating the range in meters to the retro detector unit (target range), the angle can be converted to a hit point (expressed in meters) in relation to the detector.

#### **(12) Information transmission.**

Note. Refer to detail 6 of Figure 2.

- (a) Hit point information is transmitted to the target vehicle so that the target system, mounted on target vehicle, can calculate where the hit occurred and the extent of the damage to the vehicle (probability of kill).
- (b) Hit point information is transmitted in coded form during the intervals between laser lobe pulses (see Figure 10). The laser lobes transmit not only hit point information, but also vehicle identity and the type of ammunition fired.

#### **(13) Evaluation of reflections and laser lobe sweeps.**

Note. Refer to detail 7 of Figure 2.

- (a) Reflections are evaluated on two occasions:
  - 1. After one sweep with the lobes
  - 2. After two or three sweeps
- (b) When a lobe sweeps past a retro detector unit, 6-7 pulses are reflected. The average value of these pulses is calculated and stored in the transceiver unit (see Figure 11). During a sweep, a number of reflections from each lobe and each retro detector are averaged and stored. Evaluation is carried out after three sweeps. If all three sweeps contain reflections from the same target, the average value is calculated. The point of impact is checked against a target template (see Figure 12).

### B-3. PGS FIRING SYSTEM (Con't).

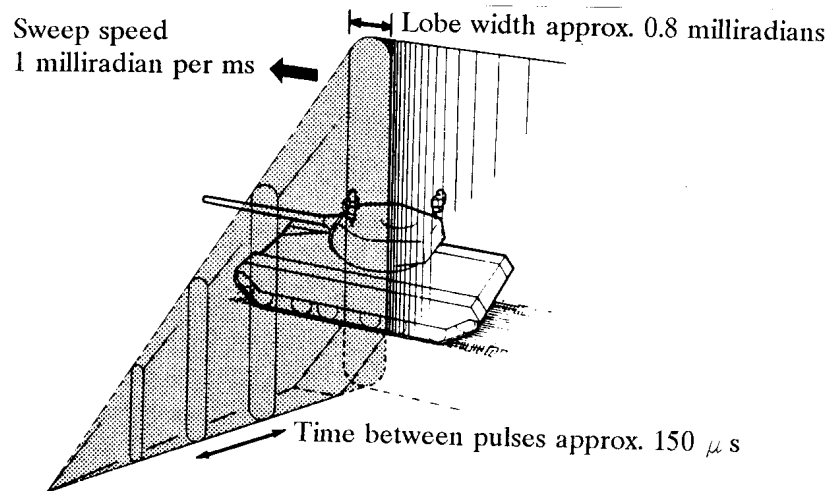


Figure 11.

- (c) If the point of impact lies within the area covered by the target template, the round is considered as being aimed at this target (see Figure 12). As a result, the tracer becomes brighter to simulate the projectile's burst, after which the burst is extinguished and the simulation is stopped. After simulation, the firing result is presented on the control panel and stored on the TDRS memory card for AAR (see detail 9 of Figure 2).

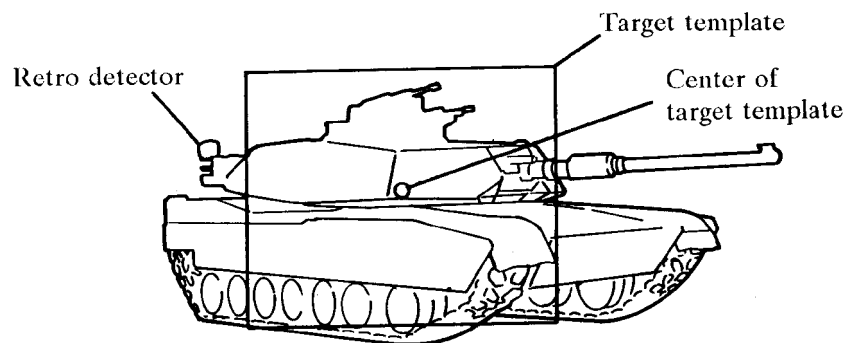


Figure 12.

- (d) If the point of input lies outside the template, the tracer and simulation continue until another target is hit or until the maximum range of the ammunition has been reached. The maximum range corresponds to the maximum range for the ammunition fired, that was programmed on the TDRS memory card and downloaded into PGS at powerup.

#### **B-4. PGS TARGET SYSTEM (Con't).**

##### **(14) Hit templates used.**

Note Refer to detail 7 of Figure 2.

##### **(a) Panel gunnery.**

1. During panel gunnery, the template used to evaluate hit or miss depends on which ammunition type the gunner has fired. For ammunition intended to kill tanks, a T80 frontal target is assumed. For ammunition intended to kill APCs, a BMP front is assumed. For ammunition used to engage personnel, a kneeling soldier is assumed.
2. PGS is designed so that the panel target has a retro reflector unit installed in the center of mass. Any other installation will give an incorrect engagement result.

- (b) Force-on-force.** During force-on-force, the system uses the same template to evaluate hit or miss for all ammunition types. The template used compensates for the position of turret-mounted retro detector units in relation to the center of mass of the vehicle. This centers the template around the center of mass of a vehicle.

##### **(15) MILES transmission.**

Note. Refer to detail 8 of Figure 2.

After a completed PGS simulation, the transceiver unit transmits MILES information. If the control panel indicates HIT, the transceiver unit transmits MILES to the target that was hit. If a ground hit is indicated, MILES is transmitted at the ground position.

##### **(16) End of firing simulation.**

Note. Refer to detail 9 of Figure 2.

- (a)** After a completed simulation cycle, the result is presented to the commander/crew on the control panel. The result presented indicates engagement result (HIT, NEAR MISS, GROUND HIT, etc.), impact point, range to target, and ammunition fired.
- (b)** This result, together with additional information such as time of round fired, identity of firing system, remaining ammunition, and selected weapon system data, are stored on the TDRS memory card for AAR.
- (c)** The weapon system data contains information such as selected range in weapon system, turret/hull relation, selected ammunition, fired ammunition, etc.

#### B-4. PGS TARGET SYSTEM (Con't).

- a. The target computer unit is used to calculate the effects of hits on target (kill probability). The effect of a projectile depends on where it strikes and the type of ammunition being used. The target computer unit determines whether the penetration point falls within the exposed target area of the tank and calculates the effect (probability of kill) of the simulated projectile on the target.
- b. A complete target system simulation cycle is illustrated in Figure 13 and described as follows.

##### (1) Information reception.

Note. Refer to detail 1 of Figure 13.

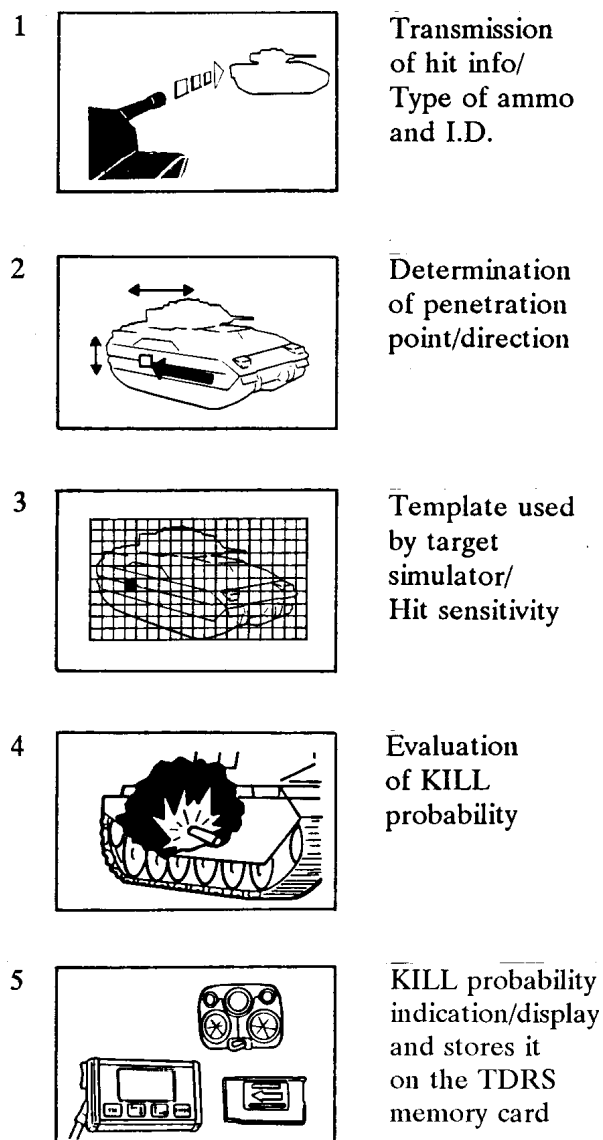


Figure 13

### B-3. PGS FIRING SYSTEM (Con't).

- (a) Hit point information, sent by the transceiver unit of the firing tank, is received by laser detectors in the retro detector units mounted on the target tank's turret (see Figure 14). The retro detector units are mounted in fixed directions around the tank, providing 360° coverage. The target computer unit is connected to all retro detector units and hull defilade detector units.
- (b) The target system determines which detector has received information by determining the direction of the incoming laser light. When information is received by the retro detector units, this information is provided to the target computer unit which performs all calculations.

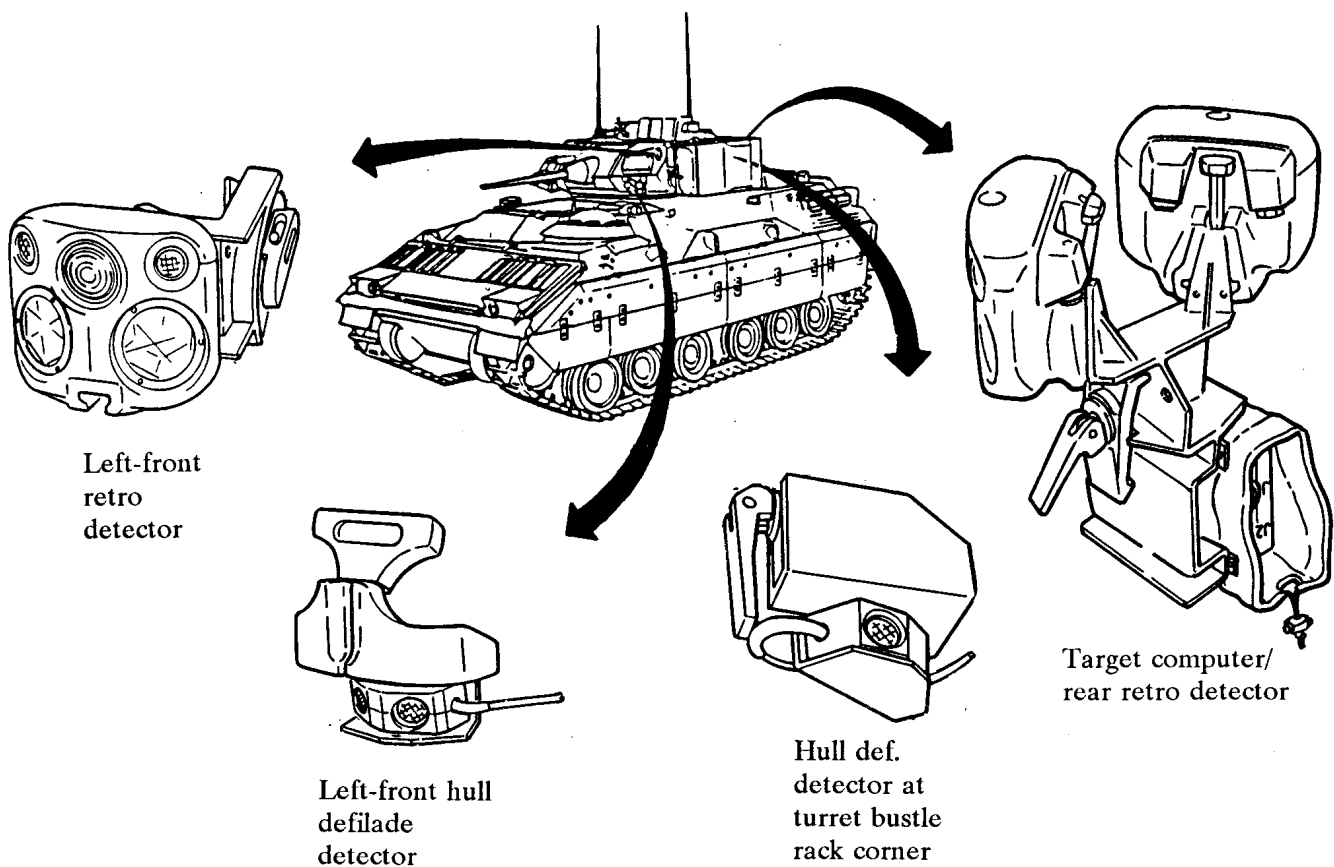


Figure 14.



### B-3. PGS FIRING SYSTEM (Con't).

- (c) Before the flying volume, and thus the simulated projectile, reaches the target vehicle, the firing system of the firing vehicle sends out information that does not contain hit point data (see Figure 15). This information is ignored by the target computer unit of the target vehicle. Nothing is stored as results until an actual hit point is determined. When an actual hit point is determined, this information is stored for evaluation using the TDRS computer unit.

#### (2) Penetration point and penetration direction.

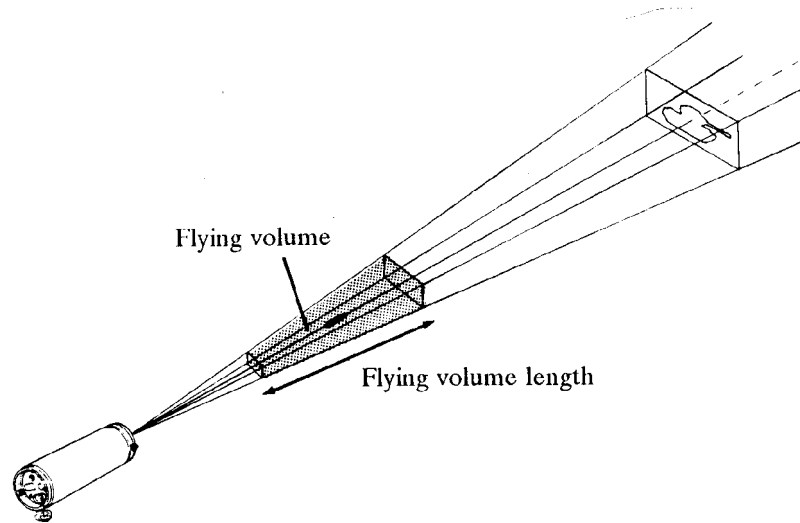


Figure 15.

Note. Refer to detail 2 of Figure 13.

- (a) Hit point information, transmitted to the target as a value in relation to the retro detector unit, is re-calculated by the target computer unit to represent an azimuth and elevation distance in relation to the center of mass of the target tank.
- (b) The target can be hit simultaneously by simulated projectiles from more than one firing tank. If this happens, the target computer unit evaluates each impact separately. No accumulative effects are calculated if the same area is hit several times.
- (c) The impact direction is determined by evaluating which of the detectors received the hit point information. Eight detectors, two in each retro detector unit, are used to calculate 12  $30^\circ$  sectors. Each sector is programmed to represent the target size and vulnerability.

### B-3. PGS FIRING SYSTEM (Con't).

- (d) If the penetration point is determined to be above the turret/hull rotation point, the direction indicated by the retro detector units is used. If the hit is determined to be below the rotation point, the direction is determined by the hull defilade detector units. If the hit is determined to be below the rotation point (hull) and the hull defilade detector units DO NOT detect any laser light, the hit is determined to be in the berm of a tank in defilade position (see Figure 16). This tank is not killed and can continue to fight.

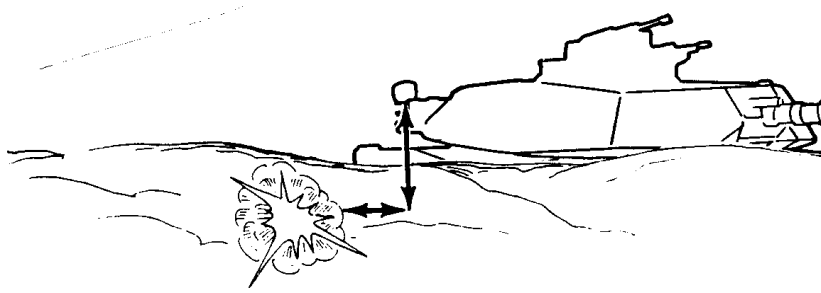


Figure 16.

#### (3) **Template used by target computer unit.**

Note. Refer to detail 3 of Figure 13.

- (a) The target computer unit uses a template in which the contour of the target is viewed from a particular direction. There are 12 templates, one for each of the 12 impact direction sectors.
- (b) The templates consist of a grid made up of small squares. Each of these squares provides information of the probability of kill of the target for each type of ammunition used. This information is used to calculate the kill probability of each round impact.

#### (4) **Kill probability.**

Note. Refer to detail 4 of Figure 13.

### **B-3. PGS FIRING SYSTEM (Con't).**

- (a) The effect (kill probability) of a round on the target is calculated from information about the type of round fired and the impact area's probability of kill. The information sent to the target computer unit includes the type of ammunition used. Other needed information is retrieved from data that was downloaded into the target computer unit from the TDRS memory card at PGS powerup.
- (b) The probability of kill calculation provides the following results:
  - 1. NEAR MISS
  - 2. HIT (no kill)
  - 3. WEAPON KILL
  - 4. MOBILITY KILL
  - 5. KILL
- (c) The impact point can lie outside the target outline. In such cases, the target registers NEAR MISS. If the impact point is inside the target outline, the result is HIT. If the hit is determined to be in the tracks or where weapon system components are located, this is indicated on the control panel.
- (d) Once a hit is determined, a random number between 1% and 100% is generated. If this number is higher than the probability of kill determined for the impact point, the target tank is killed. If the random number is lower than the probability of kill for the impact point, the target tank indicates HIT, WEAPON KILL, or MOBILITY KILL.
- (e) The purpose of the random number is to make the simulation more realistic since a highly effective hit will usually, but not always, destroy a tank. Similarly, an ineffective hit will sometimes destroy a tank.

#### **(5) Target system indication.**

Note. Refer to detail 5 of Figure 13.

- (a) NEAR MISS is indicated by two flashes from the retro detector unit strobe light.
- (b) A hit that does not kill is indicated by four to six strobe light flashes.
- (c) A hit which kills a tank is indicated by continuous strobe light flashes. A killed tank cannot resume fighting until the system has been reset by an instructor using the control gun.
- (d) If MOBILITY KILL is presented on the control panel, the crew must stop the tank within 30 seconds or catastrophic KILL will be indicated.

### **B-3. PGS FIRING SYSTEM (Con't).**

#### **(6) End of target system simulation.**

Note. Refer to detail 5 of Figure 13.

- (a) After a completed simulation cycle, the result is presented to the commander/crew on the control panel. The result indicates kill probability (NEAR MISS, HIT, MOBILITY/WEAPON KILL, and KILL), impact angle, and impact point.
- (b) This target result indication, together with additional information such as time of impact and identity of attacker, are stored on the TDRS memory card for AAR.
- (c) Weapon system data such as selected range in weapon system, turret/hull relation, selected ammunition, fired ammunition, etc. is also stored on the TDRS memory card for AAR.

#### **(7) Target simulation.**

If the firing system is MILES-equipped only, the evaluation is performed in a similar manner. PGS receives information from the attacking MILES and determines direction and effect of the MILES firing simulation. The result of the attack is stored in the TDRS memory card.

- Notes:
- 1. MILES does not send impact point information (i.e., impact point information is not stored with the results on the TDRS memory card).
  - 2. MILES codes received are IAW the enhanced MILES code structure.